

January 24, 2020

Ex Parte Filing

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12 Street SW
Room TW-B204
Washington, DC 20554

Re: ***Ex Parte* Presentation, Unlicensed Use of the 6 GHz Band - ET Docket No. 18-295;
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz - GN
Docket No. 17-183**

Dear Ms. Dortch:

On January 7, 2020, representatives of the 5G Automotive Association (“5GAA”) met with Commission staff in the Office of Engineering and Technology (“OET”) to discuss 5GAA’s positions regarding out-of-band emissions (“OOBE”) from unlicensed operations in the 6 GHz band into the 5.9 GHz band.¹ During that meeting, OET staff posed some technical questions requiring further consideration by 5GAA. 5GAA hereby responds to those questions below.

Q1. What Interference/Noise (“I/N”) value is used in 5GAA’s interference analysis submitted in Attachment 1 to 5GAA’s 6 GHz Letter?²

5GAA did not assume an I/N ratio, but instead computed the I/N as shown on slide 9 of Attachment 1 to the 5GAA 6 GHz Letter. The I/N values on slide 9 assume an unlicensed device aggressor radiating an OOBE level of -27 dBm/MHz that is received by a C-V2X vehicle-to-vehicle (“V2V”) victim antenna placed at the locations shown on slide 5. 5GAA’s testing illustrates that an unlicensed device’s OOBE at -27dBm/MHz in close proximity to a V2V receiver will cause harmful interference to C-V2X operations.

¹ See Letter from Sean T. Conway, Counsel for the 5G Automotive Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 18-295, GN Docket No. 17-183 (Jan. 9, 2020). The Commission has proposed to designate the upper portion of the 5.9 GHz band for cellular vehicle-to-everything (“C-V2X”) operations. See *Use of the 5.850-5.925 GHz Band*, Notice of Proposed Rulemaking, ET Docket No. 19-138 (rel. Dec. 17, 2019).

² See Letter from Sean T. Conway, Counsel for the 5G Automotive Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 18-295, GN Docket No. 17-183 (Dec. 9, 2019) (“5GAA 6 GHz Letter”).

The high I/N results show a clear coexistence problem exists in most areas of the vehicle. This interference can be addressed by additional OOB suppression or a larger isolation in frequency between the aggressor transmitter and victim receiver.³

Q2. What OOB limit would be needed to protect C-V2X operations from unlicensed transmitters using the lowermost U-NII-5 unlicensed channel in very close proximity to a C-V2X receiver assuming the FCC does not impose any other restriction on use of that unlicensed channel?

Assuming a sensitivity loss of 1 dB and noise figure of 11 dB (and as a consequence -108.9 dBm/MHz interference at the receiver and 81.9 dB coupling loss from -27 +108.9), the additional attenuation needed to protect C-V2X vehicle safety communications would be 81.9 dB – 33.2 dB = 48.7 dB based on the measurements in Attachment 1 of the 5GAA 6 GHz Letter. Some attenuation, potentially 12 - 15 dB, may be achievable from using directional antennas, improved polarization discrimination, and careful transceiver placement, among other design and installation modifications. This leaves at least 33.7 dB of additional necessary suppression, which would reduce the OOB level from -27 dBm/MHz to more than -60 dBm/MHz.

Adopting a tighter OOB limit for very low power (“VLP”) and mobile hotspot operations would allow for unrestricted U-NII-5 lowermost channel operations. OOB suppression to -60 dBm/MHz into the 5.9 GHz ITS band from 14 dBm EIRP VLP devices should be technically achievable.

Q3. What is the expected C-V2X range reduction due to interference from unlicensed devices in adjacent bands?

As 5GAA explained in its January 7th meeting with OET staff, interference to the C-V2X receiver affects the minimum detectable signal in noise and thus reduces the communications range. Depending on the channel conditions, including Line-of-Sight versus Non-Line of Sight operations and the range of distance under consideration, the received signal power decreases with distance by 20 to 40 dB/decade. In the worst case, range reduction can be as high as 50% for each 6 dB of unwanted noise from unlicensed operations, and 20 dB of unwanted unlicensed noise reduces C-V2X range by 90%. High levels of interference, such as from a VLP device operating inside the car causing an I/N of 43 dB, obviously renders the communications link unusable for C-V2X vehicle safety applications.

³ The coupling loss 5GAA measured on one vehicle varied from 33.2 dB in the worst case to 68.2 dB in the best case. 5GAA computed the I/N values on slide 9 by assuming the U-NII-5 aggressor antenna radiated OOB at -27dBm/MHz and measured the resulting interference received by the victim antenna, expressing that value as the ratio of the thermal noise power (KTB) in a 10 MHz channel, where K = Boltzmann’s constant; -228.6 dBW/Hz/K, T = 3,500K (system noise figure, NF = 11 dB) and B = 10 MHz (*i.e.*, the V2V channel bandwidth) resulting in a noise power of = -93 dBm.

Q4. Where on vehicles are C-V2X receivers installed?

Vehicle manufacturers need the flexibility to integrate C-V2X antennas both inside and outside the vehicle where a reliable signal propagation path, and thus maximum range, can be established. Installation may be on the vehicle roof, side mirrors, rear-view mirror, and windshield, among other locations. Locations inside the vehicle cab may be necessary for convertibles and other types of vehicles that do not have a hard roof.

Q5. Is antenna diversity used and does it reduce the impact of unlicensed interference?

Vehicle antenna diversity is used for C-V2X systems, but its use is not universal. While a diversity receiver can provide up to 3 dB of gain in theory, the actual gain will be much less if one of the paths is completely blocked such as from vehicle body blocking and other obstruction issues encountered by vehicle antenna placement restrictions.

Most importantly, the amount of gain from diversity is in no way sufficient to counter the interference from in-vehicle unlicensed operations in the lowermost U-NII-5 channel compliant with the FCC's proposed -27 dBm/MHz level. As noted above, in-vehicle unlicensed operations in the lowermost U-NII-5 channel would need to meet a -60 dBm/MHz OOB level to adequately protect V2V operations in the 5.9 GHz band.

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This notice is being filed in ECFS and provided to the OET staff copied below, all of whom attended the January 7, 2020 meeting with 5GAA. Please do not hesitate to contact the undersigned with any questions.

Sincerely,

5G Automotive Association

/s/ John Kwant

John Kwant

Ford Motor Company

5GAA US Task Force Chair

/s/ Dean Brenner

Dean Brenner

Qualcomm Incorporated

*5GAA US Task Force Vice
Chair*

/s/ Nancy Bell

Nancy Bell

Intel Corporation

*5GAA US Task Force Vice
Chair*

Exhibit:

- (1) Letter from Sean T. Conway, Counsel for the 5G Automotive Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 18-295, GN Docket No. 17-183 (Dec. 9, 2019)

cc : Bahman Badipour
 Michael Ha
 Ira Keltz
 Nicholas Oros
 Aspasia Paroutsas
 Jamison Prime
 Ronald Repasi
 Hugh Van Tuyl

Exhibit

**Letter from Sean T. Conway, Counsel for the 5G Automotive Association, to
Marlene H. Dortch, Secretary, Federal Communications Commission**

Filed Dec. 9, 2019 in ET Docket No. 18-295, GN Docket No. 17-183

December 9, 2019

Ex Parte Filing

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12 Street SW
Room TW-B204
Washington, DC 20554

**Re: Unlicensed Use of the 6 GHz Band - ET Docket No. 18-295; Expanding Flexible Use
in Mid-Band Spectrum Between 3.7 and 24 GHz - GN Docket No. 17-183**

Dear Ms. Dortch:

Earlier this year, the 5G Automotive Association (“5GAA”)¹ filed comments in the above-referenced dockets supporting the efforts of the Federal Communications Commission (“FCC” or “Commission”) to identify new unlicensed opportunities in the 5.925 to 7.125 GHz band (the “6 GHz band”).² As 5GAA explained, these efforts must include the adoption of safeguards ensuring 6 GHz band unlicensed operations do not cause harmful interference to Cellular Vehicle-to-Everything (“C-V2X”) in the adjacent 5.85 to 5.925 GHz band (the “5.9

¹ 5GAA is a global cross-industry association of companies working to develop end-to-end connectivity solutions for intelligent transportation, future mobility systems, and smart cities. Since its founding in 2016, 5GAA has grown from eight members to over 130 — including many of the world’s leading automotive, technology, and telecommunications companies.

² See Comments of 5GAA, ET Docket No. 18-295 (Feb. 15, 2019) (“5GAA Comments”). Unless otherwise stated, citations herein to comments and reply comments refer to those filed in ET Docket No. 18-295 and/or GN Docket No. 17-183.

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GHz band”). To that end, 5GAA identified certain criteria that would ensure adequate protection of C-V2X.

In this submittal, 5GAA is pleased to inform the Commission of its modified, more permissive position on adjacent band interference from 6 GHz unlicensed operations. This position is informed by the results of recent real-world tests assessing the impact of out-of-band emissions (“OOBE”) from 6 GHz unlicensed operations on C-V2X. Notably, these real-world tests indicate a fixed outdoor unlicensed Access Point (“AP”) operating in the lowest 6 GHz U-NII-5 channel at 36 dBm EIRP should not cause harmful interference to C-V2X transceivers operating at 5.905-5.925 GHz, assuming the AP meets the proposed -27 dBm/MHz OOBE limit. Accordingly, 5GAA no longer deems it necessary to prohibit fixed outdoor unlicensed operations at 36 dBm EIRP under Automated Frequency Coordination (“AFC”) control (and OOBE no greater than -27 dBm/MHz) in the 6 GHz band.³

However, 5GAA real-world testing confirms certain other unlicensed operations in the lowermost U-NII-5 channel will cause harmful interference to C-V2X. Specifically, Very Low Power (“VLP”) unlicensed operations at 14 dBm EIRP in the lowermost U-NII-5 channel and at a -27 dBm/MHz level within a C-V2X-equipped vehicle will cause harmful interference to C-V2X. Therefore, to the extent the Commission decides to allow VLP or mobile hotspot operations in the 6 GHz band, such operations should be prohibited in the lowermost U-NII-5 channel,⁴ *i.e.*, channel center frequency $f_c < 5925 \text{ MHz} + \text{BW} \times 3/2 \text{ MHz}$, where BW is the unlicensed channel bandwidth. This prohibition is consistent with 5GAA’s position in its earlier comments.

The real-world tests 5GAA conducted to arrive at these conclusions are detailed in Attachment 1 to this letter. As further explained, the harmful interference identified by this testing is the result of insufficient isolation between unlicensed device transmitters and C-V2X

³ 5GAA hereby reiterates its support for FCC action to open the lowermost U-NII-5 channel for Low Power Indoor (“LPI”) unlicensed operations as well as outdoor operations at standard unlicensed power levels under control of an AFC system.

⁴ 5GAA recognizes that the FCC may not approve VLP operations in the 6 GHz band given the substantial opposition in the record to unrestricted VLP operations and the fact that such operations were not proposed in the NPRM. *See Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Proposed Rulemaking, 33 FCC Rcd 10496, 10525 ¶ 82 (2018) (“NPRM”); *see also, e.g.*, Letter from Michael P. Goggin, AT&T Services, Inc., to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 (Nov. 12, 2019); Letter from Kara Graves, Director, Regulatory Affairs, CTIA, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 (Nov. 15, 2019); Letter from Donald J. Evans & Mitchell Lazarus, Counsel for the Fixed Wireless Communications Coalition, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 (Oct. 31, 2019).

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receivers. 5GAA also responds below to those parties who oppose any restrictions on unlicensed use of the lowermost U-NII-5 channel.

Protection of Transportation Services in the 5.9 GHz Band is Critical to Roadway Safety and America's Global Competitiveness in Connected and Autonomous Vehicle Technology

Numerous commenters in this proceeding have noted the importance of protecting vehicle safety communications in the 5.9 GHz band from adjacent channel OOB interference from new unlicensed operations in the adjacent 6 GHz band.⁵

The Friday Institute for Educational Innovation at North Carolina State University ("NC State Friday Institute"), for example, supports Commission action to open the 6 GHz band for unlicensed broadband connectivity, while detailing the critical importance of protecting Intelligent Transportation System ("ITS") vehicle safety applications.⁶ It explains that "vehicles illegally passing school buses that are stopped, with flashing red lights, and children embarking or disembarking the bus is a serious safety concern" for North Carolinians, and that safety services supported by the 5.9 GHz band can address these concerns.⁷ The NC State Friday Institute explains that the Commission thus should pursue the important task of making additional spectrum available for unlicensed broadband use in a manner that does not place roadway safety applications at risk.

Volkswagen also expresses support for opening the adjacent 6 GHz band for unlicensed broadband use while noting the importance of protecting ITS operations from 6 GHz OOB interference.⁸ Volkswagen explains that interference reduces the "reception probability of ITS packet data in an unforeseeable manner and hence prohibits many of the intended use cases."⁹

⁵ See, e.g., 5GAA Comments at 3-4; Reply Comments of Panasonic Corporation of North America (Mar. 18, 2019) ("Panasonic Reply Comments"); Reply Comments of the Association of Global Automakers, Inc. (Mar. 18, 2019); see also Reply Comments of the Alliance of Automobile Manufacturers (Mar. 18, 2019); Comments of Toyota Motor Corporation (Feb. 15, 2019); Comments of Volkswagen Group of America (Feb. 15, 2019) ("Volkswagen Comments").

⁶ Comments of the Friday Institute for Educational Innovation at North Carolina State University at 6 (Feb. 13, 2019).

⁷ *Id.* (citing North Carolina School Bus Safety Web study detailing more than 3,000 school bus stop-arm violations in a single school day, <http://www.ncbussafety.org/StopArmViolationCamera> (last visited Dec. 9, 2019)).

⁸ Volkswagen Comments.

⁹ *Id.*; see also Reply Comments of the BMW Group (Mar. 15, 2019).

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In addition, Qualcomm supports opening the 6 GHz band for unlicensed use, but explains that OOB from nearby unlicensed operations in the lower portion of the proposed U-NII-5 band can significantly degrade ITS safety-of-life operations.¹⁰ And Panasonic voices support for both unlicensed operations in the 6 GHz band and 5GAA's OOB proposal to protect ITS operations at 5.9 GHz. Specifically, Panasonic notes that unlicensed "mobile access points in handheld devices — including those operating in vehicles — may be close to vehicles and cause harmful interference to ITS communications."¹¹

These comments and others like them demonstrate the widespread support — including among automotive stakeholders — for implementing adequate safeguards that prevent harmful interference to ITS operations in the 5.9 GHz band if the FCC opens the adjacent 6 GHz for new unlicensed services.

The Proposed -27 dBm/MHz OOB Limit Will Protect C-V2X from Harmful Interference Caused by Low Power Indoor and Fixed Outdoor Unlicensed Operations, But Very Low Power Operations at this OOB Level Inside Vehicles Will Cause Harmful Interference

Regulators and industry stakeholders alike have identified the upper 20 MHz of the 5.9 GHz band, *i.e.*, 5.905-5.925 GHz, for initial C-V2X operations.¹² These operations can greatly improve roadway safety, mobility, and efficiency. To accomplish this, however, C-V2X requires highly reliable connections free from interference.

5GAA recently conducted real-world tests to assess the impact of OOB from 6 GHz unlicensed operations on C-V2X. The objective of this testing was to identify adequate safeguards to protect C-V2X operations from interference while avoiding unnecessarily conservative restrictions on unlicensed operations in the lowermost U-NII-5 channel.

The results of this testing support three conclusions. First, the Commission must adopt the NPRM's proposed -27 dBm/MHz OOB limit on emissions into the 5.9 GHz band.¹³ As explained below, this OOB limit is necessary to protect C-V2X from interference and is consistent with the long-established limits applicable to three of the four 5 GHz U-NII sub-

¹⁰ Comments of Qualcomm Incorporated at 14 (Feb. 15, 2019).

¹¹ Panasonic Reply Comments at 3.

¹² See *Use of the 5.850-5.925 GHz Band*, draft Notice of Proposed Rulemaking, FCC-CIRC1912-YY (rel. Nov. 21, 2019) (draft circulated for tentative consideration by the Commission at its 2019 December open meeting); Petition of 5G Automotive Association for Waiver, GN Docket No. 18-357 (Nov. 21, 2018).

¹³ NPRM at 10525 ¶ 82.

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bands.¹⁴ Second, LPI and fixed outdoor unlicensed APs operating in the lowermost U-NII-5 channel at 36 dBm EIRP should not cause harmful interference to C-V2X transceivers using the 5.905-5.925 GHz portion of the 5.9 GHz band, assuming these unlicensed operations meet the proposed OOB level. And third, VLP and mobile hotspot unlicensed device operations — even if they meet the proposed OOB level — cause harmful interference to C-V2X operations due to the close proximity of the unlicensed devices and C-V2X transceiver.¹⁵ 5GAA describes these tests in Attachment 1 to this filing.

Accordingly, 5GAA respectfully requests that the FCC adopt the proposed -27 dBm/MHz level for emissions into the 5.9 GHz band and permit LPI and fixed outdoor operations at the power levels proposed in the NPRM in the lowermost unlicensed U-NII-5 channel. Furthermore, to the extent the Commission allows VLP operations in the 6 GHz band, the Commission must prohibit VLP use of the lowermost unlicensed U-NII-5 channel to ensure such operations do not occur inside vehicles.

The FCC Should Neither Adopt the Much Weaker U-NII-3 Mask Nor Permit Unrestricted Unlicensed Operations in the Lowermost Channel of the U-NII-5 Band

While the Commission proposes limiting OOB from 6 GHz unlicensed operations to an EIRP of -27 dBm/MHz, a small minority of commenters ask the Commission to allow higher emissions into the 5.9 GHz band. Broadcom proposes the adoption of the U-NII-3 mask that would allow much higher emissions into the 5.9 GHz band. Broadcom also proposes to permit unrestricted unlicensed operations in the lowest channel of the proposed U-NII-5 band. NCTA proposes the same mask as Broadcom, but acknowledges it would accept the proposed -27 dBm/MHz level were the Commission to adopt that level.¹⁶

5GAA's Proposal to Protect C-V2X Operations is Not Extraordinary and Will Not Impact the Economic Use Case for VLP Devices. In contrast to NCTA's reasonable approach to OOB, Broadcom alleges that 5GAA's proposal to protect ITS operations is a "severe" and "extraordinary measure" that would "cripple RLAN operations" in the proposed U-NII-5 band.¹⁷ 5GAA reminds Broadcom that the NPRM's proposed -27 dBm/MHz out-of-band emissions level currently applies to three of the four 5 GHz U-NII sub-bands. Moreover, Broadcom's assertion that the U-NII-3 band is a success because of the highly relaxed emissions mask is without any basis in fact. Truth be told, the FCC adopted the very relaxed mask for U-NII-3 devices in part

¹⁴ See *id.* See also 47 C.F.R. § 15.407(b)(1), (b)(2), & (b)(3) (requiring U-NII out-of-band emissions to be limited to -27 dBm/MHz).

¹⁵ See 5GAA Comments at 5-7, App. B.

¹⁶ See Reply Comments of NCTA – The Internet & Television Association at 6 (Mar. 18, 2019).

¹⁷ See Reply Comments of Broadcom at 2, 17 (Mar. 18, 2019).

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because Broadcom's older model chips could not adequately lower their emissions.¹⁸ In contrast, 6 GHz unlicensed operations will be supported by newer chipsets and Broadcom should have no problem complying with the FCC's proposed -27 dBm/MHz limit. The -27 dBm/MHz emissions level is thus technically achievable and — along with limiting the lowermost U-NII-5 channel to fixed outdoor and LPI unlicensed uses — necessary to protect the licensed ITS band.¹⁹

In addition, contrary to Broadcom's assertions, prohibiting VLP use of the lowermost U-NII-5 channel in the 6 GHz band does not impact the economic case for unlicensed VLP applications. Indeed, many other channels in the vast 6 GHz band would remain available for VLP use. Moreover, the overwhelming majority of unlicensed access points will not be affected by the prohibition on VLP use in the lowermost U-NII-5 channel. The RKF Engineering study, submitted by a group that included Broadcom, determined that 98% of unlicensed access points would be installed indoors.²⁰ It is thus clear that Broadcom's claims on this topic ring hollow.

C-V2X is Ready for Widescale Deployment. Broadcom's primary objection to out of band interference concerns appears not grounded in engineering, but instead on its belief that C-V2X is a speculative service with an uncertain future. Here, Broadcom is mistaken once again. As demonstrated in 5GAA's filings to enable Basic C-V2X and Advanced C-V2X in the 5.9 GHz band, C-V2X services are ready for deployment. Ford Motor Company has committed to deploy C-V2X in all new vehicle models beginning in 2022, and a number of other major carmakers are actively assessing the technology. This momentum will increase next year, when 3GPP includes C-V2X features in the next 5G standard.

The Commission recognizes that C-V2X is moving forward. Later this month, the Commission will vote on a Notice of Proposed Rulemaking proposing to allocate the 5.905-5.925 MHz portion of the 5.9 GHz band for C-V2X operations. In light of these developments,

¹⁸ See *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Memorandum Opinion and Order, 31 FCC Rcd 2317, 2321 ¶ 14 (2016) ("Broadcom believes the change is necessary because of an artifact that occurs outside of the in-band wanted emissions in certain of their current model chips.").

¹⁹ See Attachment 1 (concluding "[c]oexistence is not practical for VLP or mobile hotspot operations within a vehicle with an OOB EIRP density of -27dBm/MHz due to the close proximity from the unlicensed device to the C-V2X receive antenna.").

²⁰ See RKF Engineering Solutions, LLC, *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band*, at 15 (Jan. 2018) ("The combined forecast of Wi-Fi and small cell outdoor shipments is approximately 1% of total units in 2021. Doubling this figure yields a conservative ratio for indoor vs. outdoor RLANs in all sub-markets of 98% and 2% respectively.") (citation omitted).

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the Commission must adopt rules for 6 GHz unlicensed operations that adequately protect C-V2X operations in the upper 20 MHz of the 5.9 GHz band.

Broadcom's Technical Assertions Ignore Common Operational Scenarios

Broadcom's analysis of the likelihood of interference to C-V2X operations in the upper 20 MHz of the 5.9 GHz band from U-NII-5 operations is not born out by 5GAA's measurements as detailed herein. Notably, Broadcom ignores the reality that unrestricted unlicensed operations, if permitted in the lowermost U-NII-5 channel, would encompass signals from multiple unlicensed devices in very close proximity — including from inside moving vehicles — to C-V2X transceivers. The test results in Attachment 1 demonstrate that such unlicensed operations will exceed the undesired emissions level of -100.4 dBm/MHz for C-V2X.

In addition, 5GAA has prepared a technical response to Broadcom's claims that 6 GHz licensed fixed service ("FS") operations just above the 5.9 GHz band will cause more interference to C-V2X operations in 5905-5925 MHz than the proposed unlicensed use in 6 GHz. The analysis in Attachment 2 shows the energy from 6 GHz licensed FS links within the 5.9 GHz band to be well below the undesired emissions level of -100.4 dBm/MHz for C-V2X even in worst-case conditions. In practice, the interference to C-V2X systems would be substantially less than this due to spatial separation and obstructions due to clutter around roadways. Therefore, the OOB from licensed FS links operating just above 5.9 GHz will not cause harmful interference to C-V2X operations operating at 5905-5925 MHz.

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While 5GAA supports FCC efforts to identify new unlicensed opportunities in the 6 GHz band, it is essential that the Commission implement rules that protect C-V2X operations in the 5.9 GHz band in accordance with this submittal.

Sincerely,

/s/ Sean T. Conway

Sean T. Conway

Counsel to the 5G Automotive Association

Atts.

- (1) 6 GHz Out-of-Band Emissions (OOBE) Limits – Testing of Impact of Proposed U-NII-5 Unlicensed Devices on C-V2X Receiver Sensitivity
- (2) Out-of-Band Emissions (OOBE) from 6 GHz Licensed Fixed Service (FS) Links

cc (w/ Atts.): Bahman Badipour
Patrick Forster
Howard Griboff
Michael Ha
Ira Keltz
Julius Knapp
Nicholas Oros
Aspasia Paroutsas
Barbara Pavon
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Karen Rackley
Ronald Repasi
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6 GHz Out-of-Band Emissions (OOBE) Limits – Testing of Impact of Proposed U-NII-5 Unlicensed Devices on C-V2X Receiver Sensitivity

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Protecting Licensed ITS 5.9 GHz Band Operations

- The 5.9 GHz licensed ITS band supports safety-of-life vehicle communications
 - Out-of-Band Emissions (“OOBE”) from new 6 GHz unlicensed operations must not significantly degrade vehicle safety communications operating in the 5.9 GHz band
- New 6 GHz unlicensed operations must protect ITS operations
 - OOBE from unlicensed devices in the proposed U-NII-5 band degrade 5.9 GHz licensed ITS operations if they are in close proximity and OOBE exceeds -27 dBm/MHz
 - Very Low Power (“VLP”) devices and mobile APs may be inside vehicles with active C-V2X communications
 - Undesired emissions at a C-V2X receiver operating in 5905-5925 MHz should be below -100.4 dBm/MHz after relevant signal losses to avoid increased packet errors and loss of operating range. The minimum required C-V2X receiver sensitivity per 3GPP TS 36.101 is -90.4 dBm for 10 MHz BW.

Real World Testing

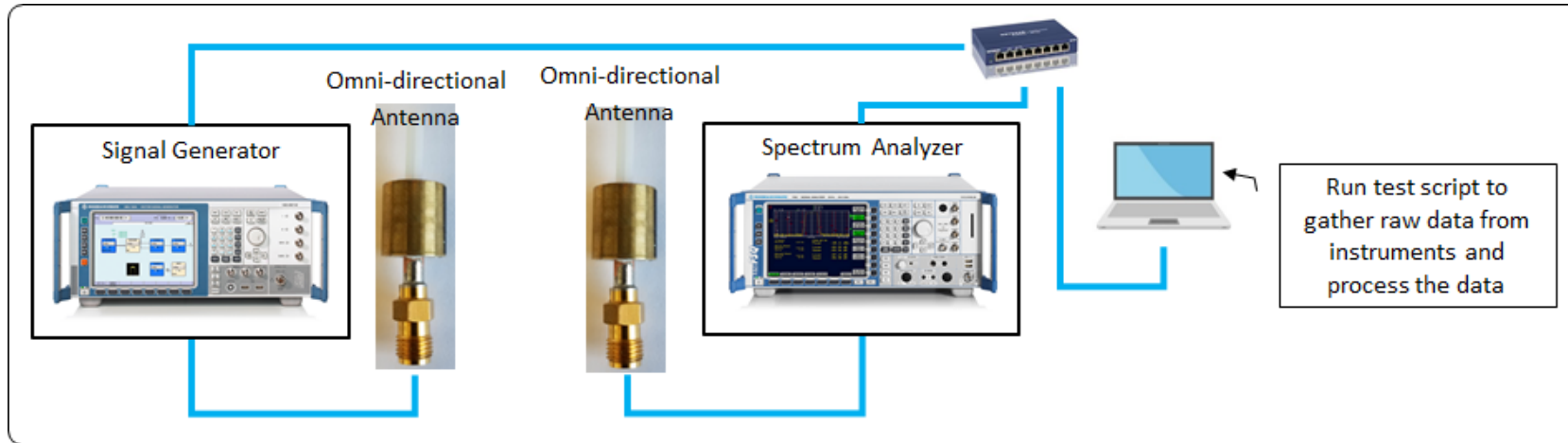
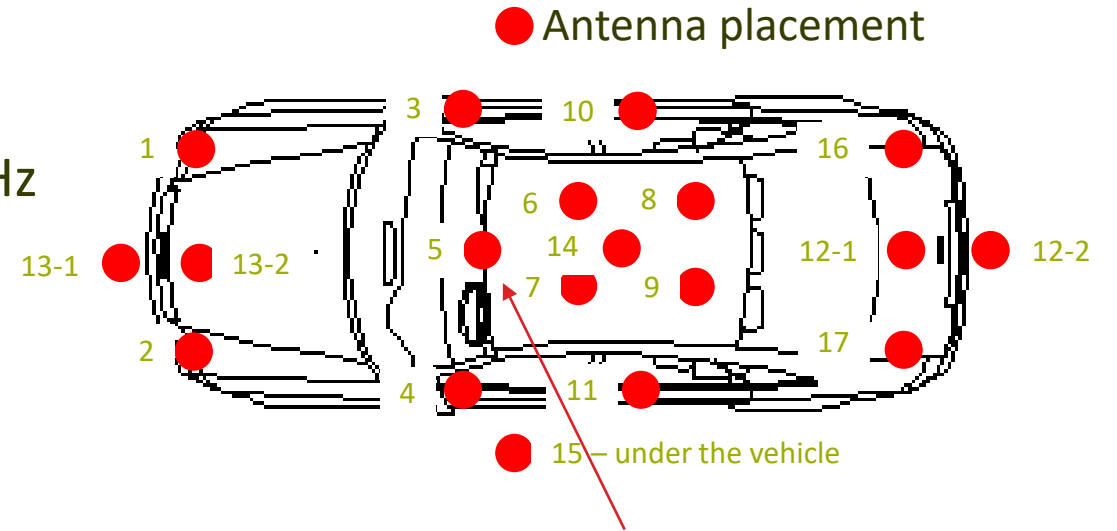
- In-vehicle testing of 6 GHz unlicensed devices using the lowermost U-NII-5 channel and presenting OOB levels of -27 dBm/MHz pose an unacceptable risk of harmful interference to C-V2X operations in the 5.9 GHz band
- Whereas real-world testing demonstrates that interference from fixed outdoor unlicensed APs operating in the lowermost 6 GHz U-NII-5 channel with -27 dBm/MHz OOB can be managed, unlicensed device operations inside of vehicles must avoid using this channel
- Unlicensed mobile hotspot and VLP devices should avoid the lowest U-NII-5 channel, i.e., channel center frequency
 $f_c < 5925 \text{ MHz} + \text{BW} \times 3/2 \text{ MHz}$

Testing of In-Vehicle Unlicensed Operations in U-NII-5 Channel to C-V2X operations in 5.9 GHz band

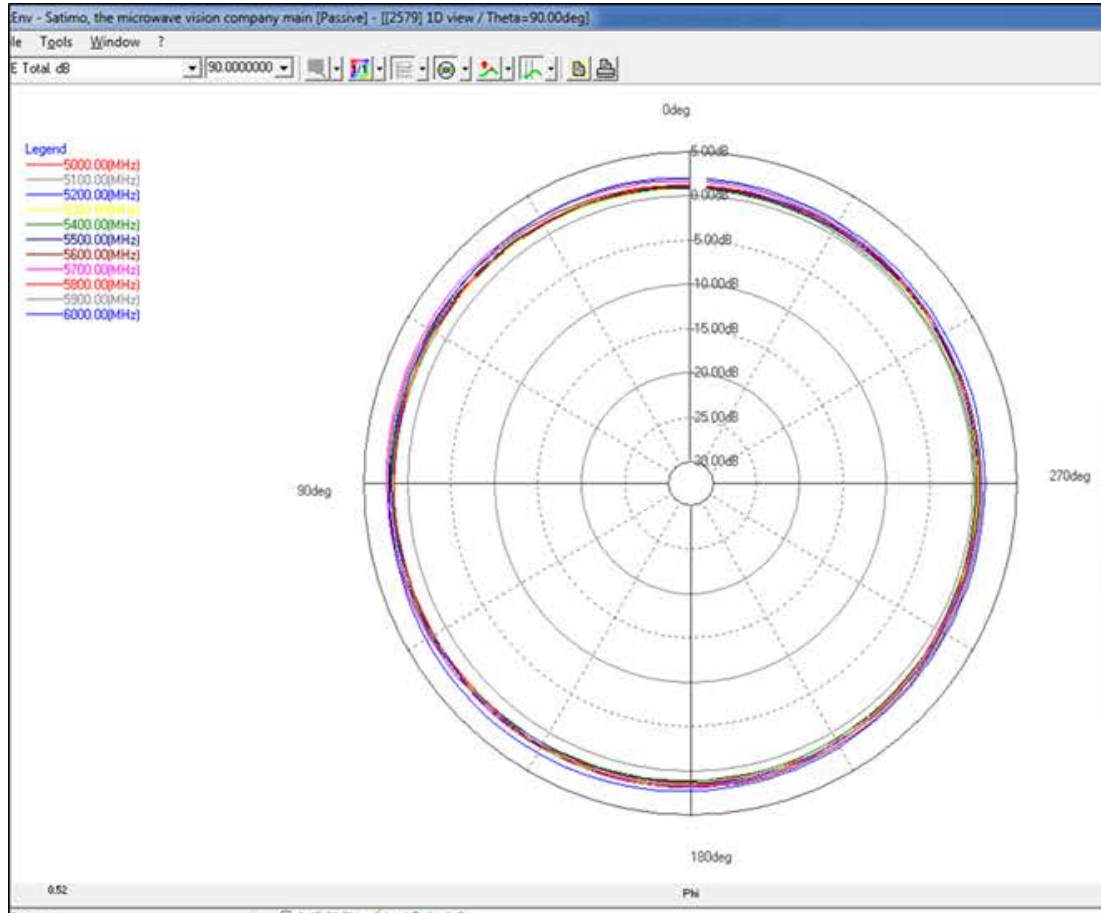
- Experiment measured propagation losses inside a vehicle and from inside-to-outside a vehicle to determine impact of unlicensed OOB to C-V2X transceivers mounted inside and outside a vehicle
- Purpose of the experiment was to quantify short-range propagation losses to assess risk of unlicensed devices interfering with V2V receivers used for C-V2X communications
- Experimental set-up, path loss measurements, observations and the assessment of the impact to a C-V2X victim receiver are provided on the following pages followed by conclusions and recommendations

Experimental Setup

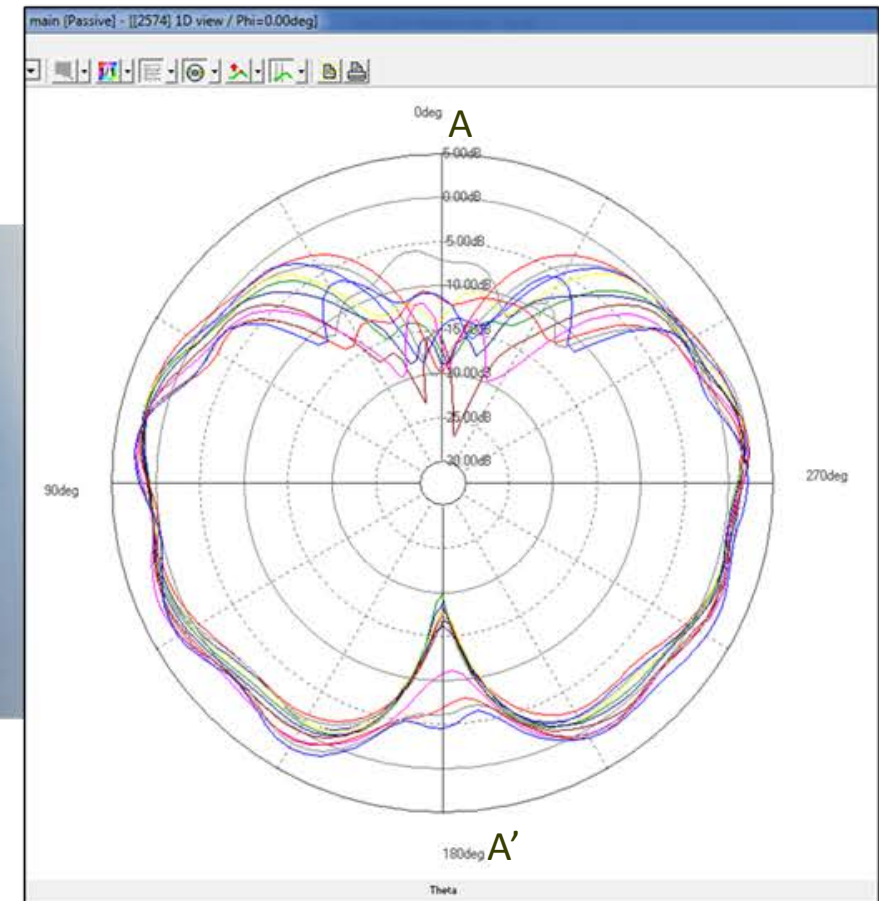
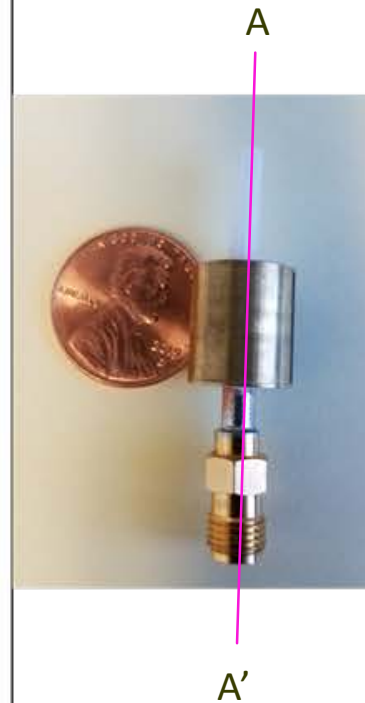
- Test vehicle: Full size sedan (Chevy Malibu)
- Test frequencies: 5725-5850 MHz, 5850-5925 MHz
- Test approach:
 - Path loss power measurements
 - Channel sounding tests for delay spread



Omnidirectional Antenna Patterns Used



azimuth cut



elevation cut

Measurement result: average path loss

	5725MHz	5850MHz	5920MHz
Total Cable Loss (2 cables)	13.8 dB	13.4 dB	13.2 dB

Path loss averaged from measurements consisting each of 20 samples collected over ~30 seconds.*

TX	RX	Windows				Trunk	Hood	Path Loss (dB)		
		Front-Left	Front-Right	Rear-Left	Rear-Right			5725MHz	5850MHz	5920MHz
Roof Center (14)	Behind dash screen (5)	open	open	close	close	close	close	60.7	60.2	68.2
Roof Center (14)	Behind dash screen (5)	close	close	close	close	close	close	60.8	59.4	64.4
Front passenger seat (6)	Behind dash screen (5)	open	open	close	close	close	close	38.4	33.2	35.2
Rear passenger seat (8)	Behind dash screen (5)	open	open	open	open	close	close	49.7	50.9	45.0
Inside trunk (12-1)	Behind dash screen (5)	open	open	close	close	open	close	46.1	70.1	53.0
Inside trunk (12-1)	Behind dash screen (5)	open	open	close	close	close	close	45.5	49.9	57.4
Outside of trunk (12-2)	Behind dash screen (5)	open	open	close	close	close	close	78.0	70.8	76.2
Outside of trunk (12-2)	Behind dash screen (5)	close	close	close	close	close	close	77.9	73.2	75.7
In front of grill (13-1)	Behind dash screen (5)	open	open	close	close	close	close	67.6	68.5	72.2
Front engine room (13-2)	Behind dash screen (5)	open	open	close	close	close	open	59.4	62.2	69.0
Front engine room (13-2)	Behind dash screen (5)	open	open	close	close	close	close	56.5	59.3	57.8
Front engine room (13-2)	Underneath vehicle dash (15)	open	open	close	close	close	close	56.4	58.9	59.6
Front-Right side (1)	Behind dash screen (5)	open	open	close	close	close	close	75.2	85.2	82.4
Front-Left side (2)	Behind dash screen (5)	open	open	close	close	close	close	68.7	81.0	84.0
Rear-Right side (17)	Front-Left side (2)	open	open	close	close	close	close	86.7	79.9	77.6
Rear-Left side (16)	Front-Right side (1)	open	open	close	close	close	close	78.2	77.0	86.1

Measurement observations

1. Roof to dash screen inside

- Roof to behind dash screen: Position 14 → Position 5 (as shown on slide 5)
- No change with windows up or down.
- Range from 6 measurements: 59.4 - 68.2 dB of loss from center roof to dash screen

2. Inside to inside

- Front seat (Position 6) and rear seat (Position 8) passenger location to behind dashboard screen (Position 5)
- No body or hand loss
- Range from 6 measurements: 33.2 - 50.9 dB
- Expect ~4 dB body loss; 0 -10 dB

3. Roof to other locations inside

There is an approximately 20 dB variation in loss within the passenger cell and the possibility of lower loss through diffraction if the roof antenna is mounted towards the rear windshield; thus, no guaranteed minimum loss may be assumed

Loss results and I/N impact to V2V victim receiver

Case	VLP Eirp density	hand loss (fixed)	body loss range assumed		Propagation path loss	Antenna type	Victim gain in direction of VLP		Power received (dBm/MHz)		Interference/noise (I/N) wrt 3GPP 36.101 N = -93dBm/10MHz	
			min	max			min	max	min	max	min	max
Roof-inside	-27	0	0	10	59.4-68.2	Omni test	0	measured	-105	-86	-2	17
Inside-inside	-27	0	0	10	33.2-50.9	Omni test	0	measured	-88	-60	15	43

Conclusion: Coexistence is not practical for VLP or mobile hotspot operations within a vehicle with an OOB EIRP density of -27dBm/MHz due to the close proximity from the unlicensed device to the C-V2X receive antenna

Conclusions & Recommendations

- To protect C-V2X safety operations in the 5.9 GHz band, these rules should govern 6 GHz unlicensed operations:
 - OOB level into 5.9 GHz band from new 6 GHz unlicensed operations must not exceed -27 dBm/MHz
 - Lowest channel in the 6 GHz band plan for VLP devices and mobile hotspots must use a channel center frequency f_c above 5925 MHz + $BW \cdot 3/2$ MHz, where BW is the unlicensed device operating bandwidth

BW (MHz)	Lowest Center Frequency (MHz) for VLP and mobile hotspots
20	5955
40	5985
80	6045
160	6165
320	6405

Attachment 2

Out-of-Band Emissions (OOBE) from 6 GHz Licensed Fixed Service (FS) Links Will Not Cause Harmful Interference to 5.9 GHz ITS Operations

The following technical analysis responds to the Reply Comments Broadcom filed in the 6 GHz proceeding. The analysis demonstrates that Out-of-Band Emissions (“OOBE”) from licensed microwave Fixed Service (“FS”) links operating just above the 5.9 GHz band are, in contrast to Broadcom’s claims, highly unlikely to cause harmful interference to 5.9 GHz ITS operations.

Operating Parameters of Licensed FS Links

Approximately 84% of the FS links licensed to operate just above 5.9 GHz use a 30 MHz bandwidth and a 66.74 dBm transmit EIRP. This analysis uses these parameters, which are consistent with those Broadcom used in the analysis in its 6 GHz NPRM Reply Comments.¹

For a 30 MHz-wide fixed link centered at 5945 MHz, the attenuation required at the 5925 MHz band-edge can be calculated as $A = 35 + 0.8 * ((5945 - 5925) / 30 * 100 - 50) + 10 * \log_{10}(30) = 63.10$ dB.² Using the average FS link EIRP of 66.74 dBm, the emission level at the upper edge of the 5.9 GHz band at the boresight of the FS transmitter is $66.74 - 63.10 + 10 * \log_{10}(1000/4) = 27.62$ dBm/MHz. The attenuation due to the FS mask would be 80 dB when ITS is operating below 5915 MHz, reducing the interference by another 17 dB (beyond the 63.10 dB of attenuation calculated above in the paragraph).

Because ITS antennas are commonly installed at the top of the vehicles (*i.e.*, the shark-fin antenna), this analysis assumes a 1.5 meter ITS antenna height. This analysis also uses an average FS antenna height of 43 meters, which is consistent with the height used by multiple commenting parties in the FCC’s 6 GHz proceeding.³ In addition, this analysis uses the Winner II Urban Macro Line-of-Sight (“LOS”) model pathloss between FS transmitter and vehicle, which is consistent with the RKF Study proffered by unlicensed advocates.

Parameters	Value	Notes
FS Bandwidth	30 MHz	
FS Transmit Power	66.74 dBm	
FS Attenuation at 5925 MHz	63.10 dB	FCC Section 101.111
FS Emission into ITS band at boresight	27.62 dBm/MHz	
FS Antenna Height	43 m	Average FS height
FS Antenna Size	6 ft and 15 ft	
ITS Antenna Height	1.5 m	
ITS Antenna gain	0 dBi	
Polarization mismatch	3 dB	
Frequency	5925 MHz	Used for pathloss calculations
Pathloss model	Winner II, LOS	

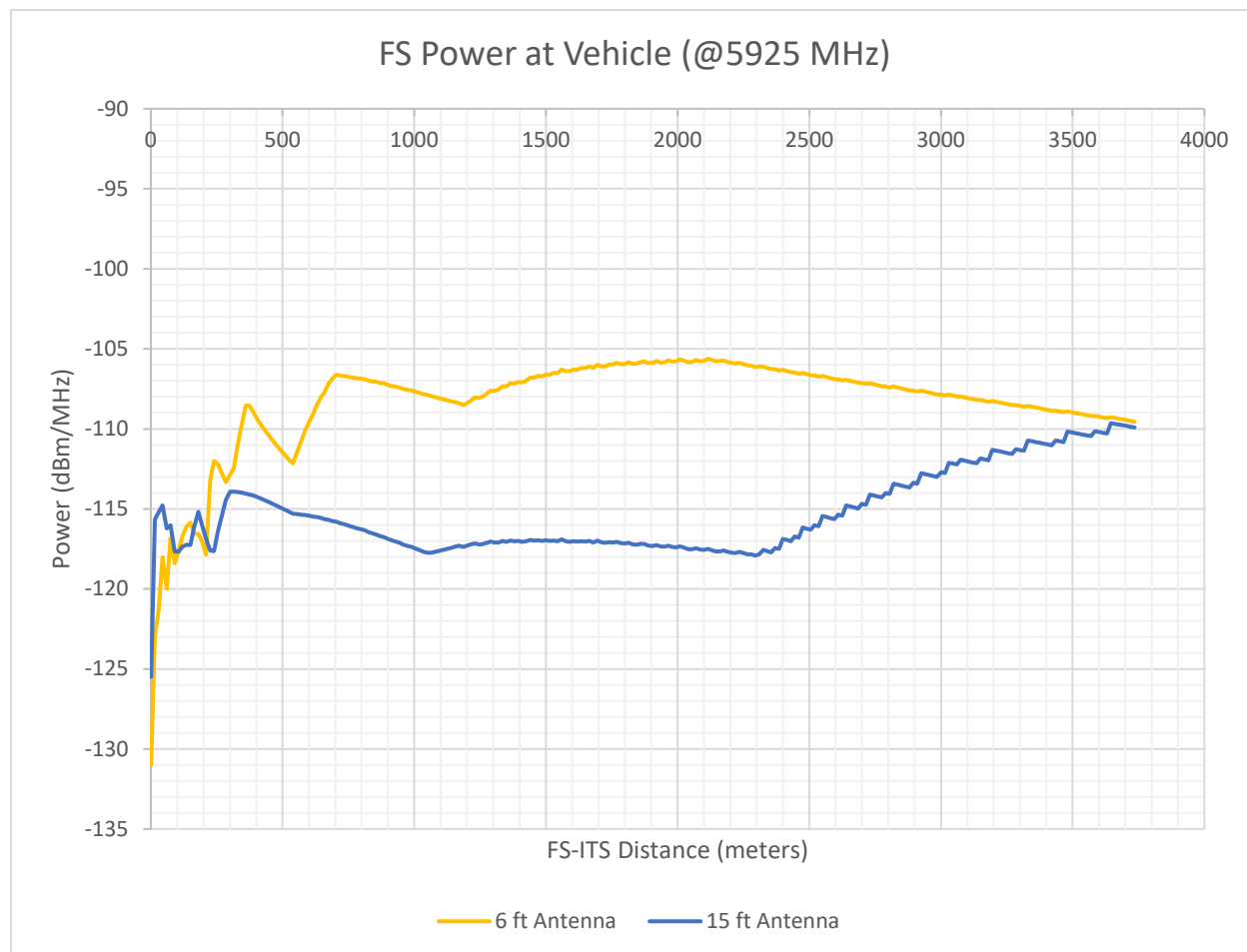
¹ See Reply Comments of Broadcom, ET Docket No. 18-295, at 23 (Mar. 18, 2019).

² See 47 C.F.R. § 101.111(a)(2)(i).

³ See, *e.g.*, Ex Parte Letter from Apple, *et al.*, ET Docket No. 18-295, at 9 (July 2, 2019).

Analysis Results and Conclusion

We have calculated the energy of the FS transmitter at the vehicle antenna, assuming worst case conditions where the vehicle equipped with an ITS transceiver is directly below the FS link and thus lacks any azimuth angle discrimination. The Figure below shows the emission into an ITS receiver as a function of distance between FS transmitter and ITS receiver.



The above Figure shows the energy from FS links within the ITS band to be well below the undesired emissions level of -100.4 dBm/MHz^4 even for the worst-case scenario where the uppermost ITS channel is considered, and the vehicle is directly below the FS link's boresight. In practice, the interference to ITS systems would be substantially less than this due to spatial separation and obstructions by the clutter around roadways. Therefore, the OOB from licensed FS links operating just above 5.9 GHz ITS operations will not cause harmful interference to C-V2X equipment operating at 5905-5925 MHz.

⁴ See Comments of 5GAA, ET Docket No. 18-295, App. B at 2 (Feb. 15, 2019).